GGS 754: Earth Science Data and Advanced Data Analysis
(Updated on Friday, January 19, 2018)

Instructor: Ruixin Yang

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Time & Place: Thursdays, 4:30pm-7:10pm, Exploratory Hall 2312
Office Hours: Tuesdays, 2:30 pm-4:30 pm or by appointment.

Text Books:
- **Text 1 (required)**: Daniel S. Wilks, 1995/2005/2011: "*Statistical Methods in the Atmospheric Sciences: An Introduction,*" Academic Press, January 1995 (ISBN: 0127519653); 2nd edition, December 2005 (ISBN-10: 0127519661); 3rd edition (ISBN-13: 978-0123850225)
- **Text 2 (recommended)**: Hans Von Storch, Francis W. Zwiers, 1999: "Statistical Analysis in Climate Research," Cambridge University Press. Paperback: January 2001. (ISBN: 0521012309); Hardback: January 1999, (ISBN: 0521450713)
- **Text 3 (recommended)**: William J. Emery and Richard E. Thomson, 1998: "Data analysis Methods in Physical Oceanography" Pergamon, 1998 (ISBN: 0080314341). [2nd Revised Edition (April 2001), Elsevier Health Sciences (ISBN-13: 978-0444507570 for paperback and ISBN-13: 978-0444507563 for hardcover)]. 3rd edition (September 2014) (ISBN-13: 978-0123877826 for paperback)

GMU Catalog Entry:
GGS 754 - Earth Science Data and Advanced Data Analysis (Credits: 3)
Covers accessing and applying Earth observations and remote-sensing data for Earth system science research and applications. Major topics are data formats, analysis and visualization tools, advanced data analysis methods, and data applications. Also covers combining innovative information technology techniques and Earth science data to set up online data centers for accessing data through the web.

Prerequisites
GGS 579 (Remote Sensing) or permission of instructor

Computing Requirements: Programming is an essential part for homework assignments and possibly for the final project. If you do not have any programming experience, you may encounter difficulty to meet the course requirements. It is your choice to use specific programming environment, tools or languages to perform the tasks. Nevertheless, for certain problems such as working with data in special formats, the choice of programming languages and environment may be limited. That means if you are not familiar with the right programming language such as Matlab, you may need to learn it or search for a substitute. Either approach may need substantially extra time. As a result, Matlab and/or IDL/ENVI are highly recommended for this course. Python can also be used for certain data formats such as HDF, netCDF, and GRIB.

Goals and Objectives:

To introduce data, data formats and data analysis methods for earth sciences. Emphasis is on advanced data analysis for time series and spatio-temporal data sets, which are widely used in publications and recently emerged.

Learning Outcomes:

After successful completion of this course,

1. Students will become familiar with earth science data in various formats.
2. Students will understand and utilize data analysis methods for Earth science data analysis.
3. Students will be knowledgeable on certain modern data analysis methods which are potentially useful for earth science data analysis
4. Students will be able to analyze earth science data sets and to write a technical report based on the analysis results.

Course Web Site: Mason Blackboard System

Grading Policy:

Homework Assignments:	50%
Final Project	50%
Total	100% (**Letter grades based on relative numbers)**

General Course Policies

- Attendance will not be considered in the final grade.
- Late assignments will be accepted in the following two days with no penalty. Late assignments beyond 2 days will be accepted and considered for the final grade. However, the late submissions will not be graded as regular submissions.
- Extra credit points may be granted to extra efforts, especially those including creative thinking.

The followings are university wide required information from Office of the Provost:

ACADEMIC INTEGRITY

GMU is an Honor Code (http://oai.gmu.edu/mason-honor-code/) university; please see the University Catalog for a full description of the code and the honor committee process. The principle of academic integrity is taken very seriously and violations are treated gravely. What does academic integrity mean in this course? Essentially this: when you are responsible for a task, you will perform that task. When you rely on someone else's work in an aspect of the performance of that task, you will give full credit in the proper, accepted form. Another aspect of academic integrity is the free play of ideas. Vigorous discussion and debate are encouraged in this course, with the firm expectation that all aspects of the class will be conducted with civility and respect for differing ideas, perspectives, and traditions. When in doubt (of any kind) please ask for guidance and clarification.

GMU EMAIL ACCOUNTS

Students must use their Mason email accounts—either the existing "MEMO" system or a new "MASONLIVE" account to receive important University information, including messages related to this class. See http://masonlive.gmu.edu for more information.

OFFICE OF DISABILITY SERVICES

If you are a student with a disability and you need academic accommodations, please see me and contact the Office of Disability Services (ODS) at 993-2474. All academic accommodations must be arranged through the ODS. http://ods.gmu.edu

OTHER USEFUL CAMPUS RESOURCES:

- WRITING CENTER: A114 Robinson Hall; (703) 993-1200; http://writingcenter.gmu.edu
- COUNSELING AND PSYCHOLOGICAL SERVICES (CAPS): (703) 993-2380; http://caps.gmu.edu

UNIVERSITY POLICIES

The University Catalog, http://catalog.gmu.edu, is the central resource for university policies affecting student, faculty, and staff conduct in university academic affairs. Other policies are available at http://universitypolicy.gmu.edu/. All members of the university community are responsible for knowing and following established policies.

Tentative Course Content (will be changed during the semester):

Week 1:   Introduction
- Course Requirements
- NASA's Earth Observing Systems (EOS)
- Related URL's

Week 2:   Theoretical Background
- Satellite Orbit Theory
  - Basics: Newton's laws and Kepler's laws
  - Circular orbits and geostationary orbits
  - Concepts of orbit elements, inclinations
  - Orbit perturbation and Sun-synchronous orbits
  - Space-time samplings
- Radiation Transfer Theory

Week 3:   Map Projections
- Basic concepts on distortions, projection planes and projection points
- Classifications
- Earth model and mathematical theory
- Mathematics of specific mappings
- Links

- o USGS Map Projections (https://egsc.usgs.gov/isb//pubs/MapProjections/projections.html)
  - o CMAPF Mapping Routines
  - o An example
  - o JazPanel

Week 4:   Data Formats
- ASCII
- Binary
  - o Demo
- GRIB;
- Assignment #1 given

Week 5:   Data Formats Part II
- HDF and HDF-EOS
  - o Demos with Grid and Swath Data
- GRIB (short introduction only)

Week 6:   Data Processing Procedures
- Measurements, Nyquist Frequency
- Data Representation
- Multi-variant data presentation
  - o Parallel Coordinate
  - o Grand Tour
- Tools: GrADS; WebWinds; IDV; CrystalVision

Week 7:   Time Series
- Basic Concepts
- TS Components
- General Decompositions
- STL Decomposition
- Assignment #1 due
- Assignment #2 given

Week 8:   Time Series (Cont.)
- Autocorrelation
- Correlations
- Assignment #2 due
- Assignment #3 given

Week 9:   Time Series (Cont.)
- Regression
- Granger Causality
- Assignment #3 due
- Assignment #4 given

Week 10:   Time Series (Cont.)-Integral Transforms
- Fourier Analysis
- Wavelet Analysis

Week 11:   Time Series (Cont.)-Integral Transforms
- Wavelet Analysis (Cont.)
- The 2nd Generation Wavelets

- Assignment #4 due
- Project outline due
- Assignment #5 given

Week 12:   Time Series (Cont.)
- HOC
- Hilbert-Huang Transformations
- Compressive Sensing

Week 13:   Principal Component Analysis
- Assignment #5 due
- Assignment #6 given (optional)

Week 14:   Nonlinear Principal Component Analysis

Week 15:   Introductions on Data Systems
- OPeNDAPS
- SIESIP and GDS
- LAS
- Project Presentation (if arranged)
- Assignment #6 due

Week 16:   Final Exam Day (**May 10th**)
- Project Report due
- Project Presentation (if arranged)
- All late HW assignments for consideration due